PATENT SPECIFICATION

(11) 1 250 729

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DRAWINGS ATTACHED

(21) Application No. 29596/70 (22) Filed 18 June 1970

(31) Convention Application No. P 19 31 444.4

(32) Filed 20 June 1969 in

(33) Germany (DT)

(45) Complete Specification published 20 Oct. 1971

(51) International Classification F 16 f 15/26

(52) Index at acceptance F1M 18

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(54) BALANCING RECIPROCATING PISTON ENGINES

(71) We, INTERNATIONAL HARVESTER COMPANY M.B.H. a Body Corporate organised and existing under the Laws of the Federal Republic of Germany, of Hansastrasse 20, 4040 Neuss-Rhine, Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to reciprocating-piston engines, in particular to internal-combustion engines, including means for counter-balancing the inertia forces of the engine.

It is usual, in order to counter-balance the inertia forces in the engines, to arrange a mass, or masses, eccentrically to the axis of rotation of the engine crankshaft or to another axis of rotation. These balancing masses, or eccentric weights, cause intermittent jerk-like loads in the engine if the engine is abruptly decelerated or accelerated. In order to reduce these loads the weights, if arranged directly on the crankshaft eccentrically to its axis, are mounted thereon by means of torsion-resilient elements. If, however, the eccentric weights are not mounted on the crankshaft, but, for example, on an auxiliary balancer including a separate shaft driven through gear wheels by the crankshaft at double the crankshaft speed, torsional vibrations will occur in the geared drive, even if the weight is resiliently mounted on its separate shaft. These torsional vibrations in addition to causing a considerable noise subject the gear wheels to a load which is a multiple of the normal load exerted upon the wheels. The main cause of these vibrations and hence of the noise and of the excessive load is essentially the comparatively wide clearance between the meshing flanks of the gear wheels which in turn is determined by the maximum tolerances of the crankshaft mounting.

The invention aims at reducing the load peaks in the geared drive between the eccentric weights and the crankshaft and at reducing the noise. Accordingly, the invention consists in a reciprocating piston engine, particularly an internal combustion engine, including a crankshaft and two rotatable eccentric weights arranged to counterbalance the inertia forces of the engine, wherein each eccentric weight is carried by a respective one of two gear wheels, wherein one gear wheel is arranged to be driven by a gear wheel mounted on the crankshaft and the other gear wheel is arranged to be driven by the one gear wheel, and wherein at least one of the gear wheels includes a torsion-resilient element located between the hub of the wheel and its toothed rim. If only one torsion-resilient element is used, it is preferable if this is fitted to the gear wheel on the crankshaft.

An advantage of an arrangement according to the invention is that the clearance between the flanks of the meshing gears may be reduced considerably since the torsion-resilient element is inherently adapted to yield in the event of the crankshaft jerking, thus preventing or at least minimising the incident of fractures. In addition the torsion-resilient element dampens the torsional vibrations so that an arrangement according to the invention reduces both, noise and excessive load on the gear wheels.

The torsion-resilient element may be a continuous ring of a resilient substance, for example rubber, which is lockingly connected to the rim and the hub of its associated gear wheel so as to transmit force between them. If a rubber ring is used as the resilient element, it may be fixed in this fashion to its associated hub and rim by means of vulcanisation. Alternatively, the torsion-resilient element may also be formed by a spring or springs or from an elastic material other than rubber. Like the continuous ring, these alternative resilient-element forming materials are arranged between the hub and the toothed rim.

According to a preferred embodiment of the invention, the external annular face of the hub — of the wheel carrying the resilient element

— is provided with a set of radially outwardly extending projections while the internal annular face of the rim is provided with a set of radially inwardly extending projections, the projections of both sets being angularly spaced and arranged relatively to one another so that the projections of the one set alternate with those of the other set. In this instance, a resilient member will be arranged in each of the spaces between any two alternating projections, the various resilient members together forming the torsion-resilient element. If, like the continuous ring, the various members consist of rubber, the latter will only be subject to a compressive load in one direction, but is not subject to an alternating load as in the case of a continuous ring so that its working life will be increased.

It is advantageous to use as the resilient substance for the ring or the resilient members a material having a natural frequency which differs from the impulses generated by the eccentric weights.

In order to make the invention more thoroughly understood, two embodiments thereof will now be described in more detail with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a front view, partly in section, of a part of a crankshaft including associated balancing means comprising two eccentric weights mounted on two gear wheels for counter-balancing the inertia forces of the engine;

Figure 2 is a cross-sectional view of the crankshaft including the gear-wheel mounted eccentric weights taken along the line II—II in Figure 1; and

Figure 3 is a cross-sectional view, on an enlarged scale, of a part of a gear wheel mounted on the crankshaft for driving one of the two eccentric-weight carrying gear wheels, the gear wheel on the crankshaft being provided with a plurality of resilient members between its hub and its rim.

Referring now to Figures 1 and 2, a gear rim 3 is fitted to the peripheral face of a web 2 of a crankshaft 1. The gear rim 3 is meshing with the teeth 6 of a gear wheel 4 which is rotatably mounted on a shaft disposed in a housing 12 arranged below the crankshaft 1. The housing 12 also accommodates a second identical gear wheel 5 rotatably mounted on a further shaft. The teeth 6 of the gear wheel 4 mesh with the teeth 7 of the gear wheel 5. Each of the gear wheels 4 and 5 carries a mass, or eccentric weight 9 and 10, respectively, each being mounted on its associated gear wheel eccentrically to the axis of rotation of the wheel. The eccentric weights serve, as well known, to compensate the vibrational forces.

The gear rim 3 includes a continuous rubber ring 16 integrally vulcanised to and between its hub 14 and its toothed rim 15 in force-transmitting fashion. This ring serves as a torsion-resilient element. Due to the eccentric weights 9 and 10 on the gear wheels 4 and 5 torsional vibration of the teeth occurs which produces peak loads. These are a multiple of the load normally acting upon the teeth flanks during normal rotation of the gear wheels 4 and 5. The torsion-resilient element, i.e. the rubber ring 16, reduces these torsional vibrations and thus the load on the teeth flanks. The torsion-resilient element instead of being built into the wheel 3 may alternatively be arranged between the teeth 6 and 7 of the gear wheels 4 and 5 respectively and their hubs. In operation when the gear rim is rotated, for example in clock-wise direction, the gear wheel 4 will rotate in the opposite, or anti-clockwise direction. Since the teeth of the gear wheel 5 only mesh with those of the wheel 4, the former will rotate in a direction opposite the wheel 4, that is to say in the same direction as the gear rim 3.

A gear rim 17 illustrated in part in Figure 3 is arranged to be mounted, like the gear rim 3 illustrated in Figures 1 and 2, on the web 2 of the crankshaft 1. However, instead of using a continuous ring as the torsion-resilient element, the latter is formed by a plurality of resilient members 20, for example of rubber. In order to accommodate these and to enable them to form a force-transmitting lock between the toothed rim 19 and the hub 21 of the wheel 17, the external annular face of the hub is provided with a set of radially outwardly extending projections 22 while the internal annular face of the rim 19 is provided with a set of radially inwardly extending projections 23. Both sets of projections are angularly spaced and the projections 22 and 23 of the two sets so arranged relatively to one another that the projections of the one set alternate with those of the other set. The members 20 are disposed in the spaces between any two projections 22 and 23. An advantage of this embodiment is that the members 20 are subject substantially only to compressive loads.

As in the case of the torsion-resilient element illustrated in Figures 1 and 2, a torsion-resilient element of the type illustrated in Figure 3 instead of being mounted on the crankshaft may be mounted on the gear wheels 4 and 5. As a further alternative, both types of the torsion-resilient element instead of being mounted on the crankshaft gear wheel only or on the eccentric-weight carrying gear wheels only may be mounted on all gear wheels.

WHAT WE CLAIM IS:—

1. A reciprocating piston engine, particularly an internal combustion engine, including a crankshaft and two rotatable eccentric weights arranged to counterbalance the inertia forces of the engine, wherein each eccentric weight is carried by a respective one of two gear wheels, wherein one gear wheel is ar-

ranged to be driven by a gear wheel mounted on the crankshaft and the other gear wheel is arranged to be driven by the one gear wheel, and wherein at least one of the gear wheels includes a torsion-resilient element located between the hub of the wheel and its toothed rim.

2. A piston engine according to claim 1, wherein the gear wheel on the crank-shaft includes the torsion-resilient element.

3. A piston engine according to claim 1 or claim 2, wherein the one gear wheel is arranged to be rotated in a direction opposite to the direction of rotation of the gear wheel on the crankshaft.

4. A piston engine according to any of the preceding claims, wherein the gear wheels carrying the eccentric weights are contra-rotating wheels.

5. A piston engine according to any of the preceding claims, wherein the torsion-resilient element is a continuous ring of a resilient substance joined to the hub and the rim in such a fashion as to form a force-transmitting lock between them.

6. A piston engine according to any of the claims 1 to 4, wherein the external annular face of the hub is provided with a set of radially outwardly extending projections while the internal annular face of the rim is provided with a set of radially inwardly extending projections, the projections of both sets being angularly spaced and arranged in relation to one another so that the projections of the one set alternate with the projections of the other set, and wherein a resilient member is arranged in each of the spaces between any two alternating projections.

7. A piston engine according to claim 5 or claim 6, wherein the resilient substance or the resilient member is rubber.

8. A reciprocating piston engine substantially as herein described with reference to Figures 1, 2 and Figure 3, respectively, of the accompanying diagrammatic drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1971.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1250729 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig.1

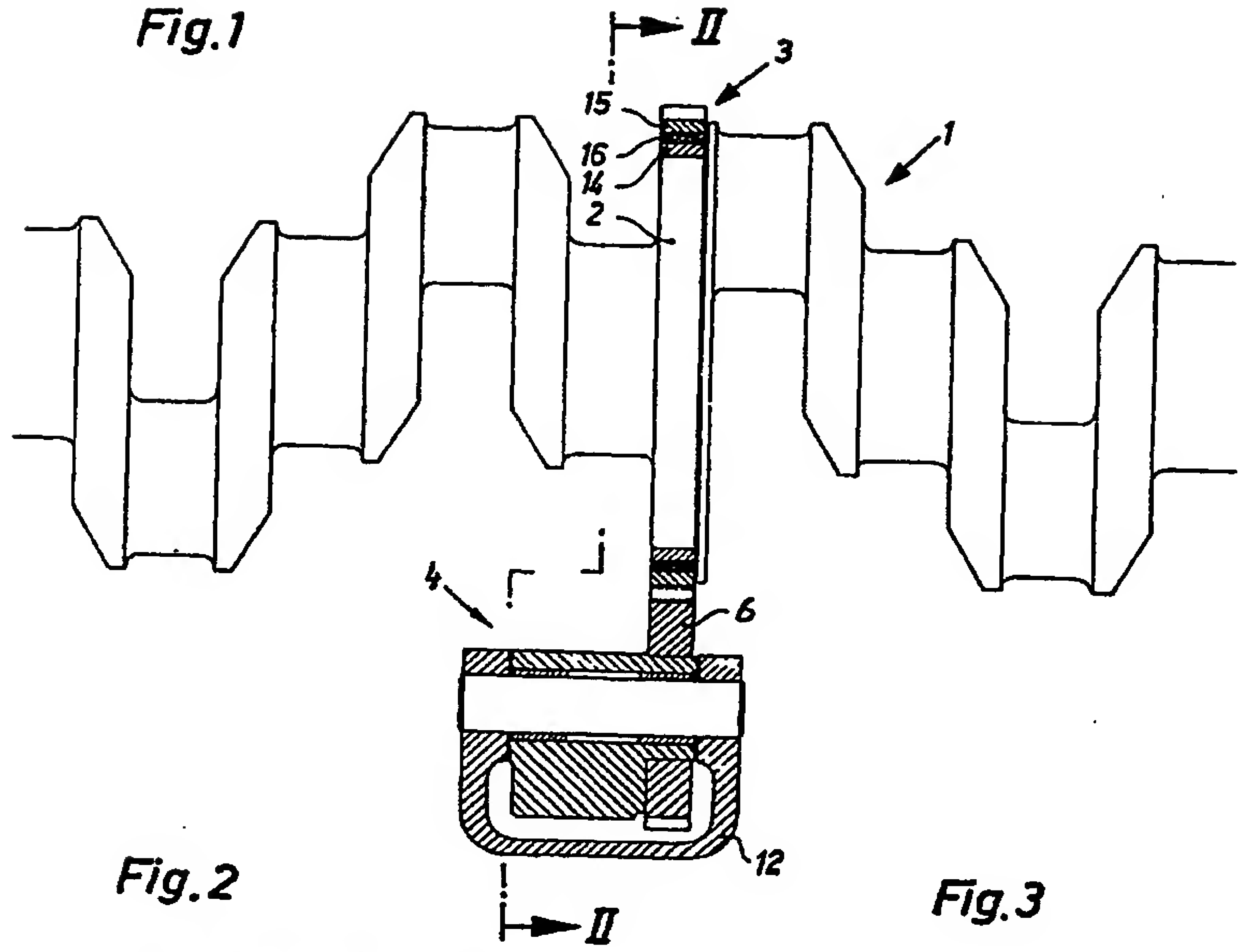

Fig.2

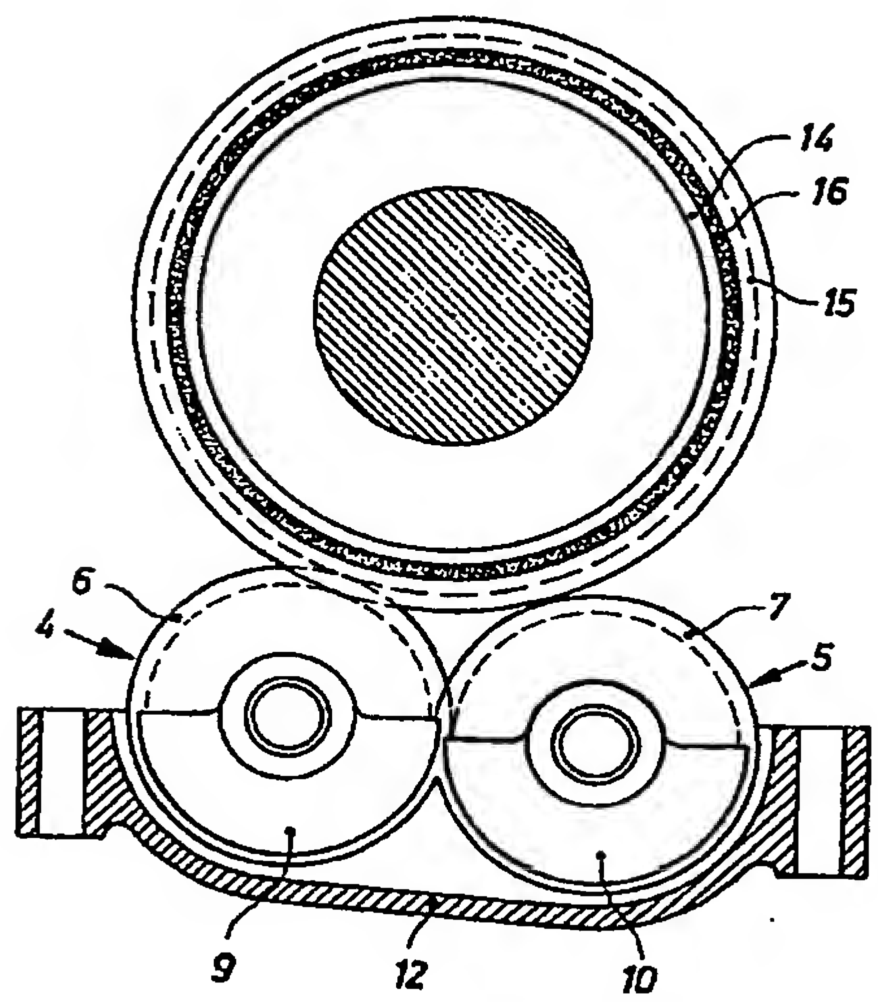

Fig.3